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Research Article

Precision Agriculture using IoT Sensor Network System – A Review

N.Anver Hussain[2], Dr. S. Saradha M.Sc., M.Phil., Ph.D.,[2]

Abstract

The demand on agriculture has been greatly intensified by a growth in the population. The present century witnesses a change from the traditional approaches to more advanced approaches with the introduction of technology. The Internet of Things (IoT) is current and future in all aspects that affect everyone's lives by making it smart. It is a network of various computers that make up a network that configures itself. The Internet of Things (IoT) has changed agriculture's efficiency and quantity. The integration of IoT, Big Data Analytics, wireless sensor networks and cloud computing offers a wide range of scope for predicting, proceeding, and analyzing circumstances and improving real-time operations. The aim is to provide a technology that records the live data of crops, soil moisture, temperature and illumination for farmers and so they can take necessary actions to do smart farming. This also enables the farmers to increase their yields with limited resources. This review outlines the importance of IoT in agricultural domain, the various components used in IoT for agriculture and finally we discussed the existing applications of IoT in agriculture.

Keywords: Internet of Things (IoT), Precision Agriculture, Wireless Sensor Networks, Applications, Smart Farming.

1. INTRODUCTION

The Internet of Things (IoT) is a network of interconnected mechanical, computing devices, and digital machines [1] with distinctive identifiers and it has a nature to transmit data across a network without the need for the communication of one human with other human or computer. The aim of the IoT is to expand internet access from mainstream devices such as computers, smartphones, and tablets to very simple devices such as water heaters, toasters, music systems etc. IoT has emerged as a powerful technique for next-generation business due to it's advanced technology of connecting end devices with system and services [2]. Smart outlets, parking sensors, activity trackers, smart city, smart home and smart supply chain are some of the applications of IoT [3].

[1]Research Scholar, Department of Computer Science School of Computing Sciences Vels Institute of Science, Technology & Advance Studies (VISTAS) Pallavaram, Chennai - 600 117. Email id : anvernoohu@gmail.com
[2]Assistant Professor, Department of Computer Science School of Computing Sciences Vels Institute of Science, Technology & Advance Studies (VISTAS) Pallavaram, Chennai - 600 117

In India, the farmers are facing with major challenges like the poor quality of seeds, ignorance of the quality and nature of fertilizers and manures, lack of mechanization and soil erosion. In order to improve smart farming strategies, a remarkable amount of research work has been done with IoT technology in agriculture [4]. By exploring various complications and difficulties in farming, IoT is doing an excellent revolution within the agriculture world [5]. Currently, the most up-to-date technology IoT is used to detect the problems, which have provided solutions to improve efficiency and also lower costs [6].

Based on the domain, the sensor type is chosen in IoT. For precision agriculture, a variety of sensors are used to provide data that helps farmers to measure soil properties like pH and soil nutrients, moisture and air permeability etc., From sensing equipments or devices, the wireless sensors collect the data and passed the data to the main servers [7]. IoT improves the cr Fop productivity by using very few resources. Figure 1 shows the main drivers of agriculture [8]. The basic foundation of IoT such as communication from sensors and the variety of services gave a thought for the researchers and scientists to do a revolution in agriculture domain. Moreover, a number of committees, food and agriculture associations, and government bodies are working on policies and guidelines to monitor and control the use of these technologies in order to ensure food and environmental protection [9-12].

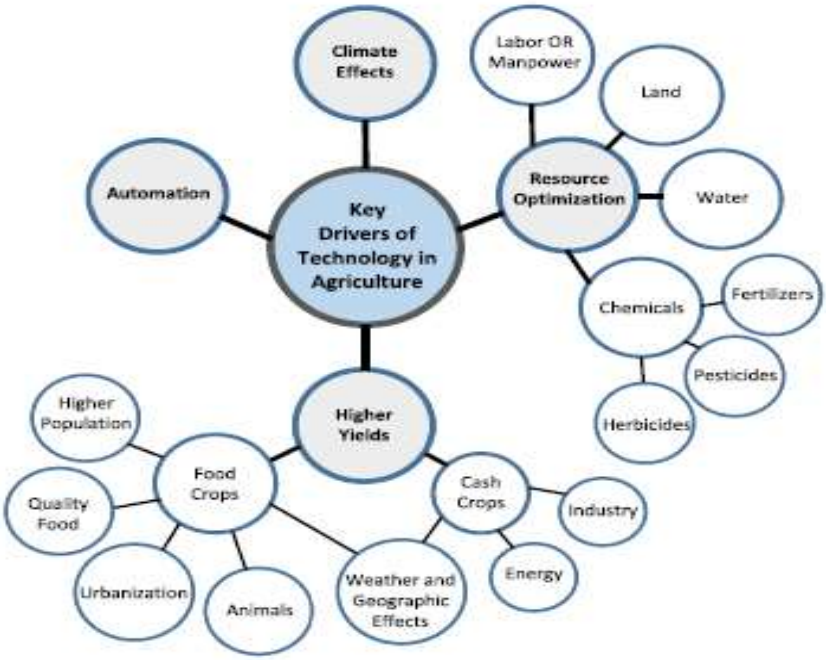

Figure 1. Key drivers of precision agriculture

2. AGRICULTURAL SENSORS

Wireless sensors play a crucial role in collecting the information about crops and it's related factors. Precision agriculture employs a range of sensors including soil, light, moisture, humidity, temperature and and many other conditions. These type of sensors are installed in IoT

based systems to collect data. The data collected by various sensors and data exchange allows the farmers to predict the crop growth in the given conditions and to design a harvesting strategy. The various sensor types used in agriculture are discussed in the following sections, along with their purpose and benefits.

2.1 Actuators

Actuators are crucial in the implementation of automation and IoT for smart agriculture. Farmers can save a lot of water by using smart irrigation, making agriculture more environment friendly. In the absence of proper actuators, these devices would not work. Automatic irrigation is achieved by using smart sprinklers and the heaters and coolers help to maintain the product durability and also reduces the waste. Intelligent LED lighting responds to changing conditions automatically, ensuring that all parts of a greenhouse and the crop warehouse receives the proper amount of light. The combined approach of lighting controls and a data analytics platform, ensures that agricultural lighting is more efficient and performs better.

2.2 Mechanical Sensors

Soil compaction also called as mechanical resistance is measured by mechanical sensors. The sensors record resistive forces using a probe (which physically acquires signals from a semiconductor device) that penetrates the soil [13]. Large tractors used this type of similar technology to forecast the pulling requirements for agricultural fields.

2.3 Electrochemical Sensors

The important details such as pH [14-15], salinity and the levels of soil nutrients, such as macro and micro nutrients are provided by implementing electrochemical sensors. The electrodes in the sensors are having the ability to identify the specific ions in farm lands. Once these sensors are mounted, they help the farmers to collect, analyse and to map the soil chemical data.

2.4 Dielectric Soil Moisture Sensors

Water quantity (the volume or percentage of water in soil) and water capacity are two related concepts in soil (the energy state of water in soil). The quantity of water in the soil by weight or volume is referred to as water content. Water potential is not the same as water quality. It refers to the soil's water's energy condition. This type of sensors measure the moisture level in the soil through the value of dielectric constant (a property that alters depending on the moisture level).

2.5 Optical Sensors

Optical sensors test soil properties using light. Sensors in the near-infrared, mid-infrared, and polarised light spectrums test varying wavelengths of light reflectance. Sensors are placed on the vehicles or remote helicopters like drones to monitor or to quantify soil organic compounds, soil colour and moisture, mineral presence and texture, clay content etc., [16-17]. These sensors evaluate the soil's capacity to react to light from electromagnetic spectrum in different sections. The changes in wave reflections help to demonstrate soil density changes and other parameters.

For simple plant evaluation, fluorescence dependent optical sensors are used, particularly to monitor the maturation of the fruit [18]. In addition, it can be used for the characterisation of olive grove canopies when combining optical sensors with microwave dispersion [19].

2.6 Airflow Sensors

Permeability means the flow of air and water across the soil, which is significant because it governs the aeration of air in plant roots, humidity and plant nutrients and thus helps in plant growth and crop production. Airflow sensors measures the soil permeability in individual locations or when moving dynamically. The output consists of the requisite pressure to force a specified air volume to the soil. Different soil properties such as compaction, composition, soil condition and humidity level, create specific signatures.

2.7 Agricultural Weather Stations

Weather stations for agriculture are autonomous systems located in different areas in the growing fields. These stations deploy various sensors suitable for local cultivations and environment. The predetermined data was measured and reported such as air temperature, leaf wetness, rainfall, wind speed, wind direction, soil temperature at different depths, soil salinity, chlorophyll, relative humidity, atmospheric pressure and solar radiation at regular intervals. The collected data are aggregated and distributed wirelessly to a central data logger. Its portability and lower costs make it appealing to farmers having farms of different sizes. The standard wireless sensor networks and IoT used for farming applications on the field is shown in Figure 2.

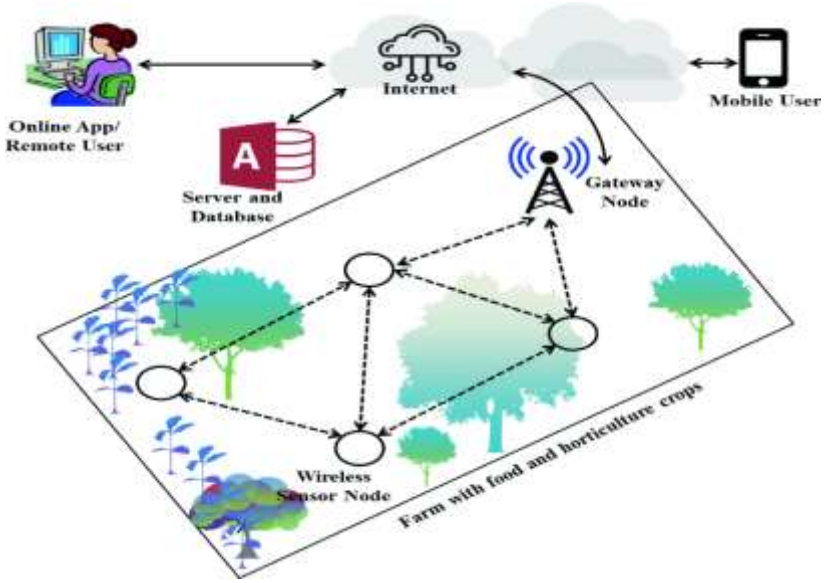

Figure 2. Deploying Wireless Sensor Networks and IoT for Precision Agriculture

3. APPLICATIONS OF IOT IN AGRICULTURE

The Internet of Things (IOT) will change the world's way of life. Each feature of conventional agriculture methods can be radically modified by the use of latest wireless sensors and IoT techniques in agricultural domain. To feed the continuous growth of population around the world, it will be better for the agriculture industry to implement IoT techniques in future. For example, the demand for more food production, the farmers should meet the challenges like climate change due to global warming, extreme and various weather conditions and environmental impact due to pollution and other farming practices. Intelligent farming by using IoT technology helps farmers minimise waste and improve productivity. Intelligent agriculture is fundamentally a hi-tech food-producing device that is clean and mass sustainable. Figure 3 illustrates some important applications of IoT for precision agriculture.

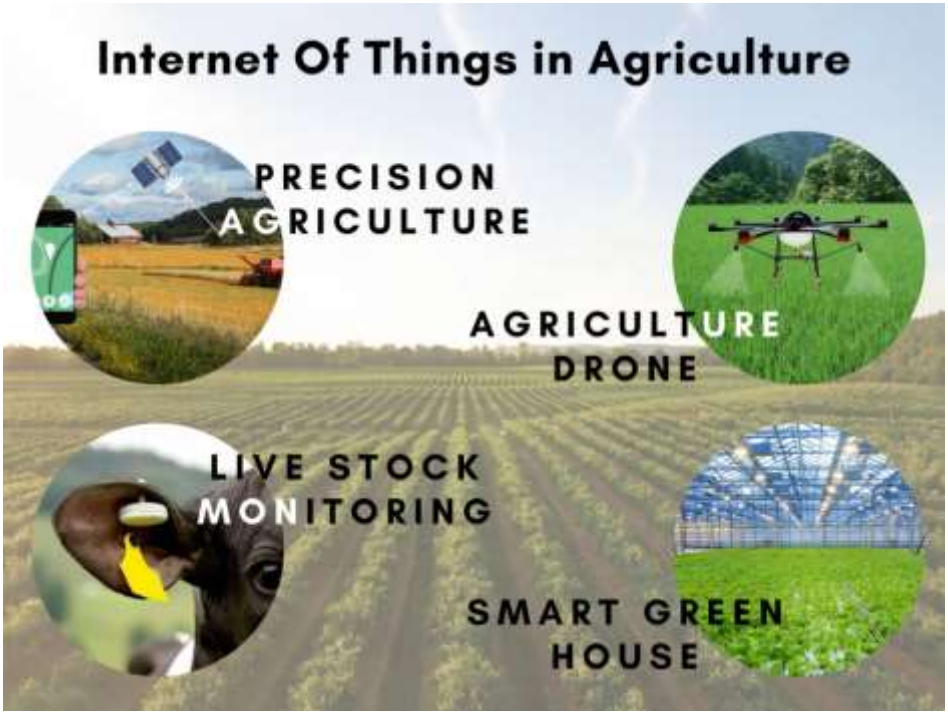

Figure 3. IoT applications in Agriculture

3.1 Precision Framing

Precision agriculture is an agricultural management term focused on the observation, estimation and responses to intra-field and intercrop variability. The aim of precision agricultural research is the development of an entire farm management decision support system with the objective of maximizing input returns while retaining capital [21-23]. The ability of farmers to find their exact location in a field allows the mapping of the spatial variations of many factors such as crop yield, nutrient content and moisture levels in soil, topography, nitrogen levels, pH, Magnesium, Potassium and other vital chemicals for plants can be determined [24]. In recent years, Precision agriculture has been one of IoT's most common applications in agriculture and numerous organizations around the world have already started to implement this technique.

In terms of satellite and aerial photography, weathers and implementation of variable fertilizer rates and crop health indices, this is the first phase of the precision agricultural revolutions. The second phase adds the computer data to make the plantation, topographic mapping and soil data much more accurate [25]. New information and communication technology make crop management at field level more practical and simpler for farmers to achieve [26]. Implemented agricultural machinery that promotes Variable Rate Technologies (VRT) requires implementation of plant management decisions. Optimizing VRI is a process which maximizes profitability on irrigated soil variability crops and thus boost yields and increase water quality. Variable Rate Irrigation (VRI) is also a process for optimizing irrigation rates. In order to improve crop productivity a correlations study was established between information on the agricultural climate and crop statistics to collect crop data.

In order to improve crop productivity a correlation study was established between information on the agricultural climate and crop statistics to collect crop data [27]. IoT-based meteorological forecasts help to maximize production and analyze crops in order to avoid damage. The prediction of pesticide behaviour, plant or seed growth and solve any pending plague problems before they affect crops are handled by multiple monitoring equipment and sensors. A platform based on IoT for agricultural accuracy and ecological monitoring was built in [28]. In [29], on the basis of tracked data a remote agricultural monitoring tool was introduced. For precision farming, a computational architecture built on cyber and information systems was presented [30]. The technology of a soil moisture sample offers full local agricultural assistance and guidance for maximizing water usage in the season. The virtual PRO optimizer integrates multiple water management tools into a central, cloud-based, and efficient location that provides consultants and farmers with a streamlined interface to do irrigation with accuracy with less resources.

3.2 Agricultural Drones

In this modern era, technology has improved and farm drones are an excellent example. Today, farming is one of the largest industry implementing drones for various activities. Soil inspection is monitored by soil and aerial drones in agriculture, field health assessment, irrigation, crop surveillance, and pest control. The main advantages of using drones are drone photography, optimized GIS (Geographic Information System) imaging, user flexibility, time saving and ability to improve returns. Drone technology would bring a high-tech crop production to the agriculture sector by using policy and planning focused on collection and analysis of data in real time.

Drones are primarily used in large farms where bacteria fungus problems need to be addressed on a regular basis. Fertilizers and pesticides are essential for crops so that it will give good yield in agriculture [31-32]. Agricultural drones show their efficiency in spraying the pesticides and fertilizers on the field with high speed. In order to achieve the business goals, an IoT based technique for farm MIS (Management Information System) has been developed [33].

3.3 Livestock Monitoring

Wireless IoT applications may be used by large farm owners to gather information about their livestock locations, welfare, and fitness. This knowledge assists with the identification of

infected animals so that they can be disconnected from the herd, thereby avoiding disease transmission. It also cuts job costs as farmers may use IoT-based sensors to identify their livestock. One approach encourages the livestock owners to watch and give birth to pregnant cows. When the water breaks from the pregnant cow, a sensor battery driven is ejected. This way, the sensor helps farmers to concentrate more on the time spent with birth-giving animals.

Because of animal disease, farmers lose a significant volume of profit every year. However, IoT-based strategies for livestock management allow farmers to improve their agricultural values, field conditions and dairy products [34]. Livestock monitoring sensors are attached to the animals to monitor their movements so that the owners can track their location and thus stopping burglary of animals. An IoT based livestock monitors are used to track the temperature, heat stress levels, physical gesture, rumination and heart rate of animals,

3.4 Smart Greenhouses

Greenhouse agriculture is a way of improving the production of vegetables, fruit, grains, etc. Greenhouses are responsible for human action or a proportional monitoring system to track environmental parameters. The approaches by human leads to production depletion, energy loss, and higher labor costs. With the aid of IoT an intelligent greenhouse can be built. This system intelligently controls and monitors the environment so that manual operation is not required. Different sensors that calculate environmental parameters based on the plant requirement are used to monitor the atmosphere in a smart greenhouse. When linked via IoT, we can build a cloud server to remotely access the device. In this way, continuous manual supervision is avoided. Recent studies demonstrate how IoT can be used in greenhouses to reduce human capital, build up electricity and directly link greenhouses between ranchers and customers. Most experiments have focused on distant and localised surveillance only [36-38].

In the greenhouse, the cloud server can also store and monitor data. This architecture provides farmers with limited manual interference with cost-effective and optimum solutions. Solar powered IoT sensors are used to build affordable and modern greenhouses [35]. This kind of sensors facilitates to create a farmer's online portal which allows to track greenhouse state and water consumption through SMS alerts. The IoT sensors at the greenhouse provide illumination, humidity, temperature and pressure information. These sensors run the actuators automatically to open a window, to turn on lamps, to control a heater, to toggle a mister or to turn the fan on by Wi-Fi.

4. CONCLUSION

Researchers across the globe are looking for technical innovations in order to increase agriculture production by using IoT. Thus, farmers and ranchers may gather meaningful data with IoT agricultural applications. Large landowners and smallholder farmers must realize the IoT demand value of agriculture through the installation of intelligent technology for increased productivity competition and sustainability. As the population grows quickly, demand can effectively be fulfilled if both farmers and smallholders are successfully implementing IoT agricultural solutions. The significance of IoT, various types of sensors used for farming and finally the most important applications of IoT for agriculture were investigated in this paper.

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